Numerical Weather Prediction

Field Modification - FSSSI/T&R Aspects

Forecasting Research Technical Report No. 378

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FORECASTING RESEARCH

TECHNICAL REPORT No. 378

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March 2002

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1. Introduction

To enable automatic corrections to Forecasting for Specific Sites: System Implementation (FSSSI) forecasts of (max and min) temperatures and rainfall, it has been proposed that adjustments be made based on the Temperature and Rainfall (T&R) forecasts, which are available at only 10 stations, using a weighting function method based on forecast error correlation characteristics.

To provide a preliminary estimate of the length scale for this weighting function the Verification Team has carried out a study to examine the correlation of errors between all FSSSI stations and T&R stations as a function of distance from each T&R station. This report outlines the scope and methodology of the study and presents results relating error correlation to the distance between T&R and FSSSI stations.

2. Data Analysis

Data analysed were for temperature and six-hourly accumulated rainfall values as predicted by both raw mesoscale (MES) and mesoscale site specific forecast (SSFM) models. These data reside in the verification Oracle tables 'cfrd.ssm_data' and 'cfrd.mes_data'. Errors to be correlated were obtained by matching forecasts to observed values.

Two month-long periods (September and December 2001) were selected for analysis. For each month, FSSSI/T&R station error correlation values were generated at 00, 06, 12 and 18z for forecast ranges T+0, 6, 12, 18, 24, 30 and 36 hours. Approximately 120 data points were used to calculate the monthly error correlation for a given FSSSI station at each forecast range. Additionally, combined forecast range error correlations that used (hourly) forecast ranges over T+0 to T+36 hours (approximately 4000 data points sampled per station) were generated. Error correlations were determined using the relationship,

$$Error_Correlation = \frac{\frac{1}{N}\sum (F_{1i} - O_{1i} - ME_1)(F_{2i} - O_{2i} - ME_2)}{\left[\frac{1}{N}\sum (F_{1i} - O_{1i} - ME_1)^2 \frac{1}{N}\sum (F_{2i} - O_{2i} - ME_2)^2\right]^{\frac{1}{2}}},$$

where F denotes forecast value, O observation value for the i^{th} observation and ME mean error from stations denoted by subscripts 1 and 2.

FSSSI error correlations against individual T&R stations were examined to determine relationships between error correlation and FSSSI to T&R station range (henceforth stated simply as 'radius'). Relationships for each T&R station were compared in order to ascertain the likelihood of geographical location affecting the error correlation versus radius distribution. Similarly, changes in error correlation versus radius distribution with forecast range value were checked. Error correlation versus radius distributions of temperature and rainfall for the September and December data, generated by combining the results from all ten T&R sites, were examined.

3. Error Correlation – FSSSI/T&R Station Range: Distribution for Combined Data

The data analysis has shown significant positive (i.e. 'in-phase') error correlations between FSSSI and T&R station errors close to any given T&R station, and that error correlations diminish fairly rapidly with increasing range between stations (radius). Some geographical trends were observed in the data; for example, the error correlation versus radius relationship was most obvious for T&R stations in the southeast (e.g. Church Lawford, Heathrow, Wattisham, where station density is relatively high), whilst error correlations were generally weaker and more scattered at some near-coastal sites (e.g. Aberdeen,

Cardiff, Stornoway). Nonetheless, error correlation versus radius relationships for the individual T&R stations appear similar enough to justify combining the data in order to determine a single lengthscale for FSSSI/T&R error correlation.

These results are shown in Figure 1, which comprises plots of combined T&R station error correlation data for September and December 2001 temperature and rainfall forecast by the SSFM (MES results were very similar). In the plots some data points take a correlation value of less than zero on the vertical axis. This might suggest an out of phase correlation, but generally these values are sufficiently small to indicate that error correlations are insignificant in these instances. Otherwise the data shows decreasing magnitude in error correlation with increasing radius.

The plots also show fits to the data of a simple relationship, with the form

$$y = \frac{a}{x + a}.$$

It is worth noting these relationships were derived using positively correlated data only, as to obtain a negative y value would require x and a to be of opposite sign, leading to an infinite return when the magnitude of x equalled that of a. However, the fit described in each of the figures (R, generally greater than 0.6) is calculated using all data. That this fit is reasonable supports the hypothesis that error correlation is inversely proportional to the radius.

The values of a also provide information on the lengthscale for the error correlation relationship. On the plots in Figure 1 are marked radius values for which the correlation falls to the square root of 0.5, calculated using

$$x = a\left(\frac{1}{\sqrt{0.5}} - 1\right).$$

These points correspond to the radius at which the centre point (T&R station) describes 50% of the variance of the test point (FSSSI station). When corrections to the centre point are applied to points at this radius, half of the benefit to the mean square error from modifying the centre point should be gained at the test point.

To illustrate this result quantitatively, a typical case is considered where RMS errors in temperature for model data are 2 °C at both center and target station. If manual modification of the forecasts at the center station typically produces a 10% improvement in RMS error, such that modified data RMS error at the center station is 1.8°C, then center station mean square errors (i.e. error variance) are 4 $°C^2$ and 3.24 $°C^2$ for model and modified data respectively. For a target station at the 50% variance radius, the improvement in mean square error between model and modified data will be 50% of that at the center station, i.e. (4+3.24)/2=3.62 $°C^2$. The corresponding target station modified forecast RMS error is thus 1.9 °C, an improvement of 5% over the model only RMS error. This benefit is relatively small, and approximating from the results in Figure 1, will decrease further for any target outside a radius of 30 km.

4. Conclusion

This preliminary study suggests that applying the type of weighted error correlation function described above to modify FSSSI stations from a modified forecast at a T&R station is only likely to be of significant benefit for stations within a relatively small radius, less than 30 km, of the centre station.

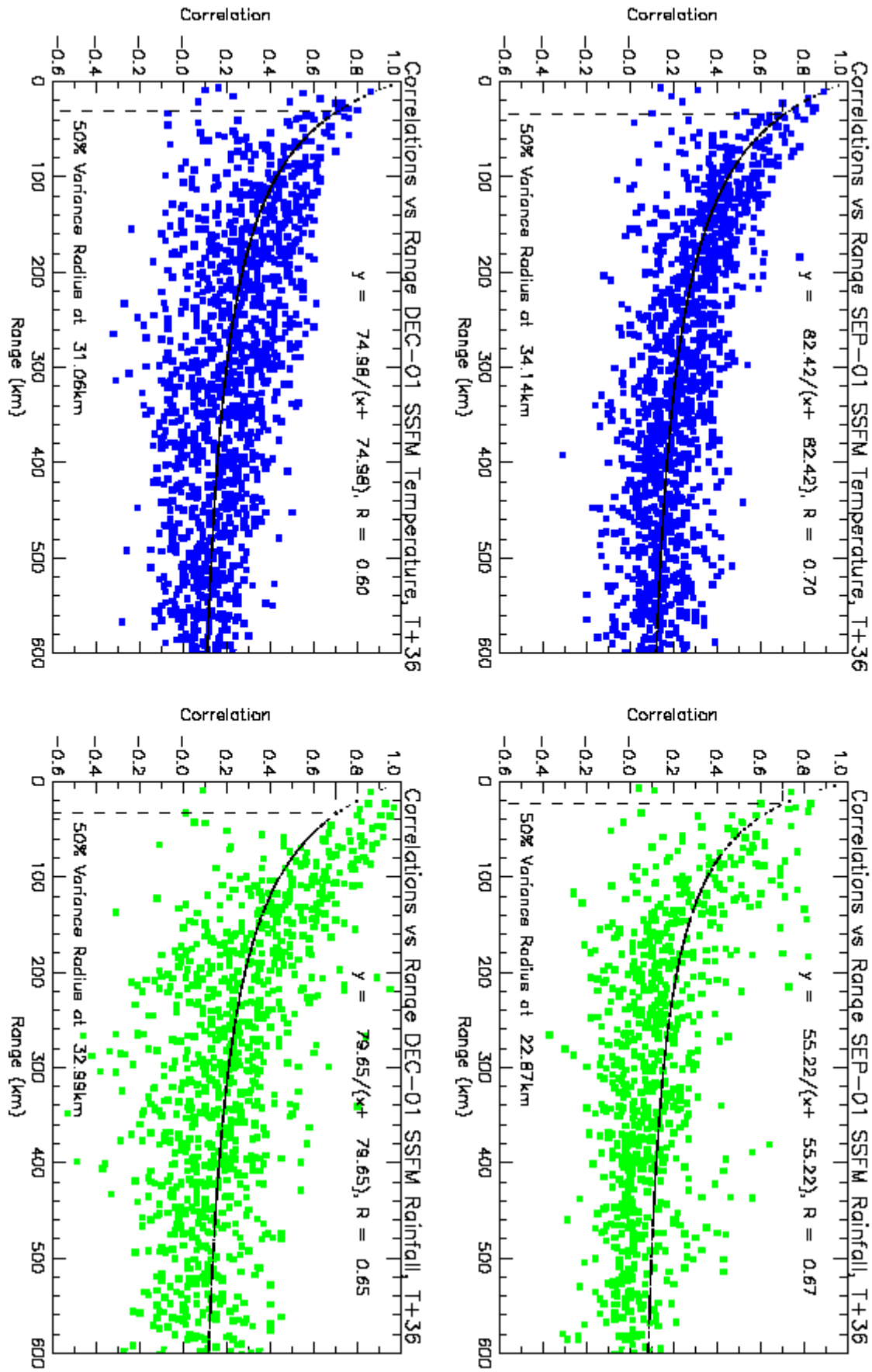

Figure 1: Error correlation versus radius plots for SSFM temperature and rainfall forecasts, September and December 2001.